



EP 1110-2-13
28 June 1996

**US Army Corps
of Engineers**

ENGINEERING AND DESIGN

DAM SAFETY PREPAREDNESS

ENGINEER PAMPHLET

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EP 1110-2-13

CECW-EP

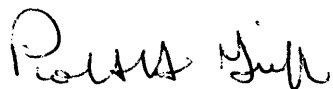
Pamphlet
No. 1110-2-13

28 June 1996

Engineering and Design
DAM SAFETY PREPAREDNESS

1. **Purpose.** This pamphlet provides general guidance and information concerning dam safety preparedness within the Corps of Engineers.
2. **Applicability.** This pamphlet applies to HQUSACE elements, major subordinate commands, districts, laboratories, and separate field operating activities having responsibility for civil works projects.

FOR THE COMMANDER:



ROBERT H. GRIFFIN
Colonel, Corps of Engineers
Chief of Staff

**DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000**

EP 1110-2-13

CECW-EP

Pamphlet
No. 1110-2-13

28 June 1996

**Engineering and Design
DAM SAFETY PREPAREDNESS**

Table of Contents

Subject	Paragraph	Page	Subject	Paragraph	Page
Chapter 1			Turnover of Completed Dam Projects		
Introduction			to Local Sponsors	3-8	3-2
Purpose	1-1	1-1			
Applicability	1-2	1-1	Chapter 4		
References	1-3	1-1	Operation and Maintenance		
Glossary	1-4	1-1	General	4-1	4-1
Objective and Scope	1-5	1-1	Operation and Maintenance Manual	4-2	4-1
Organization of Manual	1-6	1-1	Instrumentation and Monitoring	4-3	4-1
			Initial Reservoir Filling	4-4	4-1
Chapter 2			Periodic Inspection and Continuing		
General Considerations			Evaluation	4-5	4-2
Introduction	2-1	2-1	Reporting Distress	4-6	4-3
History of Dam Safety	2-2	2-1			
Federal Guidelines for Dam Safety	2-3	2-1	Chapter 5		
Administration of Dam Safety in			Rehabilitation and Modification of Dams		
the Corps of Engineers	2-4	2-2	Dam Safety Rehabilitation	5-1	5-1
Applicable Dams	2-5	2-3	Major Rehabilitation Program	5-2	5-1
Modification of Dams	2-6	2-4	Dam Safety Assurance Program	5-3	5-1
Regulatory Permit Program for			Procedural Requirements	5-4	5-3
Non-Federal Dams	2-7	2-4			
			Chapter 6		
Chapter 3			Emergency Action Plans (EAP)		
Civil Works Project Planning and Design			General	6-1	6-1
Process			Scope of Emergency Action Plan	6-2	6-1
General	3-1	3-1	Components of Emergency Action Plan	6-3	6-1
Problem Perception and Study			Number of Emergency Action Plans		
Authorization	3-2	3-1	Required	6-4	6-3
Reconnaissance Phase	3-3	3-1	Emergency Action Plan Exercises	6-5	6-4
Feasibility Phase	3-4	3-1			
Preconstruction Engineering and			Chapter 7		
Design Phase	3-5	3-1	Training		
Construction Phase	3-6	3-2	Overview	7-1	7-1
Operation and Maintenance Phase	3-7	3-2			

Subject	Paragraph	Page	Subject	Paragraph	Page
Training Program for Operations and Maintenance Personnel	7-2	7-1	Appendix D		
Corps of Engineers Training Course on Dam Safety	7-3	7-1	Construction		
Training Aids for Dam Safety	7-4	7-1	General	D-1	D-1
			Construction/Design Interface	D-2	D-1
			Problems to Watch for During Construction	D-3	D-1
			Obtaining Quality Construction	D-4	D-2
			Construction Records and Reports	D-5	D-2
Appendix A					
References					
Appendix B			Appendix E		
Glossary			Research and Development		
Appendix C			Introduction	E-1	E-1
Design			Dam Safety Research in the Corps of Engineers	E-2	E-1
Introduction	C-1	C-1	Dam Safety Research by Other Federal Agencies	E-3	E-2
Design Review	C-2	C-1	Coordination Among Federal Agencies .	E-4	E-2
Instrumentation Plan	C-3	C-1	Transfer and Integration of New Technology	E-5	E-2
Coordination Between Design and Construction	C-4	C-2			

Chapter 1 Introduction

1-1. Purpose

This pamphlet provides general guidance and information concerning dam safety preparedness within the Corps of Engineers.

1-2. Applicability

This pamphlet applies to HQUSACE elements, major subordinate commands (MSC), districts, laboratories, and separate field operating activities having responsibility for civil works projects.

1-3. References

Required and related references are listed in Appendix A.

1-4. Glossary

Abbreviations and terms which may not be familiar to the reader are defined in Appendix B.

1-5. Objective and Scope

The objective of this pamphlet is to provide necessary background information, a detailed summary of regulations and guidelines and appropriate references pertaining to dam safety. This pamphlet will assist USACE elements in their preparation for and implementation of the USACE Dam Safety Program. While it is intended for internal use, portions are applicable for use in dam safety support provided to Army, Air Force and Navy installations.

1-6. Organization of Manual

General considerations in dam safety, civil works project process, operation and maintenance, rehabilitation of dams, emergency action plans (EAP), and training are covered in Chapters 2 to 7, respectively. Design, construction, and research and development, as related to dam safety, are covered in Appendixes C to E, respectively.

Chapter 2 General Considerations

2-1. Introduction

Although it is impossible to quantify the overall safety of a dam, the way to achieve maximum dam safety is well understood, i.e., to apply the utmost care and competence to every aspect of design, construction, operation, and maintenance. Therefore, the most important prerequisite for safety of dams is the professional competence of persons associated with the dam over its life span. A dam with a record of safe performance may still experience failure due to undetected deficiencies in the dam or in the foundation. Dam safety must take precedence over all other considerations (International Commission on Large Dams 1987; National Research Council 1985; Jansen 1983, 1988b).

2-2. History of Dam Safety

a. *Early development of dams.* History indicates that dams have been a vital part of civilization for more than 5,000 years. Dams were constructed by the early settlers in the United States in the 1600's to provide water supply and power gristmills and sawmills. The oldest Corps of Engineers dams are six lock and dams on the Green and Kentucky Rivers built between 1836 and 1844 (Reed 1987, Walz 1990a).

b. *Dam safety.* Although construction of dams dates back many years, the history of dam safety covers a much shorter time span. Only a limited number of states had any type of law regulating dam safety prior to 1900. The failure of the South Fork Dam at Johnstown, Pennsylvania, in 1889 resulting in 2,209 deaths had limited influence on the dam safety programs. California initiated a dam safety program following failure of the St. Frances Dam in 1928. Failures of the Buffalo Creek Dam in West Virginia and the Canyon Lake Dam in South Dakota in 1972 contributed to Congress passing "The National Dam Inspection Act" in 1972. Failure of Teton Dam in Idaho in 1976 was followed by "The Reclamation Safety of Dams Act" in 1977. Failure of the Laurel

Run Dam in Pennsylvania and the Kelly Barnes Dam in Georgia in 1977 set in motion the development of the "Federal Guidelines for Dam Safety" issued in 1979 by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) (discussed in paragraph 2-3) (Federal Emergency Management Agency 1979). In 1979, President Carter created the Federal Emergency Management Agency (FEMA) and directed Federal agencies to adopt and implement the Federal Guidelines for Dam Safety and report their progress to FEMA on a biennial basis. In 1980, the Interagency Committee on Dam Safety (ICODS) was formed to coordinate Federal activities and work with the states to ensure implementation of dam safety practices. The Corps of Engineers is the Department of Defense representative on ICODS. In 1984, the Association of State Dam Safety Officials (ASDSO) was organized to provide a forum for the exchange of information and ideas on dam safety and to foster interstate cooperation (Association of State Dam Safety Officials 1989). Nongovernment agencies actively dealing with dam safety include the International Commission on Large Dams (ICOLD) and its United States affiliate, the United States Committee on Large Dams (USCOLD) and the Electric Power Research Institute (EPRI) (Colorado Division of Disaster Emergency Services 1987; Tschantz 1982; Reed 1987; Walz 1990a; Wiseman 1987; Jansen 1988a; Government Accounting Office 1977, 1978; Duscha 1984, 1986, 1990).

2-3. Federal Guidelines for Dam Safety

a. In 1977, President Carter issued a memorandum directing three actions:

(1) That all Federal agencies having responsibility for dams conduct a thorough review of their practices which could affect the safety of these structures and report their findings to the FCCSET.

(2) That FCCSET prepare the "Federal Guidelines for Dam Safety" for use by all Federal agencies.

(3) That ICODS be established to promote and monitor Federal and state dam safety programs.

b. In 1979, the "Federal Guidelines for Dam Safety" was published, and ICODS was given oversight

responsibility for dam safety. The key management practices outlined in these guidelines are as follows (Federal Emergency Management Agency 1979):

- (1) Establish a Dam Safety Officer and appropriate staff.
- (2) Maintain an updated inventory of dams.
- (3) Document design criteria and construction activities.
- (4) Prepare initial reservoir filling plans and reservoir regulation criteria.
- (5) Prepare operation and maintenance instructions and document activities.
- (6) Maintain a training and awareness program.
- (7) Prepare and maintain EAPs for each dam.
- (8) Establish a program of periodic inspections and evaluation of dams.
- (9) Monitor and evaluate the performance of each dam and appurtenant structure and provide remedial construction as necessary.

2-4. Administration of Dam Safety in the Corps of Engineers

a. Dam safety at HQUSACE. In February 1980, the Chief of Engineers appointed the Chief of Engineering Division, Directorate of Civil Works, as the HQUSACE Dam Safety Officer. The Dam Safety Officer chairs a standing committee composed of individuals having assigned responsibilities for dam safety (ER 1110-2-1156). The Corps' Dam Safety Officer is also the Corps' member of FEMA's ICODS (Federal Emergency Management Agency 1988b).

b. Dam safety organization. The Corps of Engineers maintains a decentralized organization of three levels. Each level is staffed with qualified and experienced personnel in areas of design, construction, and operations of dams and appurtenant structures. Each level has a Dam Safety Officer and organization

as follows (ER 1110-2-1156):

(1) HQUSACE.

(a) Organization. The standing dam safety committee members are as follows:

- Chief, Engineering Division, Directorate of Civil Works, Chairman.
- Chief, Engineering Division, Directorate of Military Programs.
- Chief, Operations, Construction and Readiness Division, Directorate of Civil Works.
- Chief, Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works.
- Chief, Hydraulics and Hydrology Branch, Engineering Division, Directorate of Civil Works.
- Chief, Structures Branch, Engineering Division, Directorate of Civil Works.
- Chief, Electrical and Mechanical Branch, Engineering Division, Directorate of Civil Works.
- Chief, Construction Branch, Operations, Construction and Readiness Division, Directorate of Civil Works.
- Chief, Policy Development Branch, Policy Review and Analysis Division, Directorate of Civil Works.

(b) Responsibilities. The Dam Safety Officer is responsible for ensuring that the Corps of Engineers maintains a proactive dam safety program and is implementing the Federal Guidelines for Dam Safety (Federal Emergency Management Agency 1979) in policy and practice and other duties as described in ER 1110-2-1156. The committee periodically reviews and evaluates design, construction, operation, maintenance, and rehabilitation programs to improve internal practices

related to dam safety; reviews the status of EAPs and

dam safety training; and reviews research and development programs to ensure that the latest technology receives consideration and evaluation. The committee meets at least semi-annually and makes periodic inspections and field visits as necessary. The committee ensures that the inventory of dams is current and adequately maintained and reviews research and development programs to ensure that the latest technologies related to dam safety receive consideration and evaluation (ER 1110-2-1156).

(2) Major Subordinate Commands (MSC).

(a) Organization. The MSC Dam Safety Officer is the Director of Engineering and Technical Services. The standing committee contains the chiefs of the same disciplines as that in HQUSACE.

(b) Responsibilities. The MSC Dam Safety Officer and committee are responsible for quality assurance coordination and implementation of the dam safety program within the MSC. The committee will conduct a minimum of two meetings per year. Their responsibilities include establishing dam safety related work priorities within the MSC, monitoring the status of EAPs, ensuring dam safety training is being conducted, ensuring that adequate data are submitted for the inventory of Corps dams, and conducting dam safety exercises (see ER 1110-2-1156).

(3) District Commands.

(a) Organization. The District Dam Safety Officer will be the Chief, Engineering Division. The standing committee will comprise the same disciplines as that in the MSC. However, the Dam Safety Officer may be located in a district responsible for the technical aspects of projects located within another districts boundaries (should a district organization not include an engineering division).

(b) Responsibilities. The District Dam Safety Officer and committee are responsible for the execution of the dam safety program. A minimum of two meetings will be held annually. Responsibilities include establishing a public awareness program with information at each project and coordination with downstream local interests, monitoring and evaluating

the performance of all dams and appurtenant structures

and recommending remedial measures when necessary,

establishing the priority of dam safety related work, conducting dam safety training, and ensuring that each dam has an adequate surveillance plan (ER 1110-2-1156).

2-5. Applicable Dams

a. Dam involvement. The Corps of Engineers involvement in dams can be categorized as follows (ER 1110-2-1156, Federal Emergency Management Agency 1992a):

(1) Dams which the Corps has designed, constructed, operates, and maintains. Ownership remains with the Corps of Engineers.

(2) Dams which the Corps has designed and constructed but are owned, operated, and maintained by others.

(3) Dams that are designed, constructed, operated, maintained, and owned by others in which flood control storage has been provided at Federal expense under the authority of the 1944 Flood Control Act.

(4) Dams for which the Corps has issued permits under its regulatory authority.

(5) Dams inspected and evaluated by the Corps under the authority of the National Program for the Inspection of Non-Federal Dams, PL 92-367.

b. Dam safety. In category 1, the Corps of Engineers has a definite responsibility for dam safety. For dams in category 2, the primary responsibility for dam safety is with the agency or sponsor which accepts the project. The Corps' responsibility in this case is a supporting consultant role. In category 3, the Corps should participate in inspections to ensure that the Federal flood control interest is being properly maintained. For categories 4 and 5, the Corps has no responsibility for dam safety (ER 1110-2-1156, Federal Emergency Management Agency 1992a).

2-6. Modification of Dams

a. Programs. The bulk of Corps of Engineers dams are over 30 years old, and many dams are over 60 years old. Aging structures and advances in technology impact on the safety of dams and require detailed reevaluation and, in some cases, modification. Rehabilitation of Corps of Engineers dams is accomplished through four programs (ER 1110-2-1155, ER 1130-2-417, ER 1165-2-119, Federal Emergency Management Agency 1992b, Walz 1990a):

(1) Major Rehabilitation Program. This program allows significant, costly, one-time structural rehabilitation or major replacement work. This work restores the project to its original condition to serve as originally intended. Work under the Major Rehabilitation Program includes dams, locks, powerhouses, and breakwaters (ER 1130-2-417).

(2) Dam Safety Assurance Program. This provides for modification of completed dams when deemed necessary for safety purposes due to new hydrologic or seismic data or changes in the state-of-the-art design or construction criteria. This program is under the authority of Section 1203 of the Water Resources Development Act of 1986 (PL 99-662) and permits the project to function effectively as originally intended. Examples of work under this program include enlarging existing facilities or constructing new facilities to provide for modifications resulting from new hydrologic or seismic data or changes in state-of-the-art design or construction criteria deemed necessary for safety purposes.

(3) Modifications to completed projects. Completed Corps projects are observed and monitored to ascertain whether they continue to function in a satisfactory manner and whether potential exists for better serving the public interest. When it is found that changes in a completed project may be desirable, investigations are undertaken to document the need for and feasibility of project modifications. To the extent possible, modifications to completed projects are accomplished under existing authorities. Significant modifications to completed projects involving new Federal construction or real estate acquisition in order to serve new purposes, to increase the scope of

services of authorized purposes beyond that intended at the time of project construction, or to extend services

to new beneficiaries, require authorization by Congress. Additional information including eligible works, local protection projects, justification and cost sharing, and multiple purpose projects is given in ER 1165-2-119.

(4) Operation and maintenance authority. To properly operate the project or minimize maintenance, reasonable changes and additions to facilities, within the project boundaries, are made as needed as part of the Corps' operations and maintenance program (ER 1165-2-119). Operation and maintenance are discussed in detail in Chapter 4.

b. Reporting sequence. Under the Major Rehabilitation and Dam Safety Assurance Programs, investigations are conducted and reports prepared to determine the need for and scope of remedial measures, and to form the basis for obtaining construction funds. Reports are followed by more detailed investigations which are reported in design memoranda. The design memoranda form the basis for preparing plans and specifications for the remedial work. More detail regarding the Major Rehabilitation and Dam Safety Assurance Programs is given in Chapter 5.

2-7. Regulatory Permit Program for Non-Federal Dams

a. Dams and dikes. Section 9 of the River and Harbor Act of March 3, 1899, charges the Chief of Engineers and the Secretary of the Army to regulate the construction of any dam or dike across any navigable water of the United States. The term "navigable waters of the United States" means those waters of the United States that are subject to the ebb and flow of the tide shoreward to the mean high water mark (mean higher high water mark on the Pacific coast) and/or those presently used or have been used in the past or may be susceptible to use to transport interstate or foreign commerce. The term "dike or dam" means any impoundment structure that completely spans a navigable water of the United States and that may obstruct interstate waterborne commerce. The term does not include weirs. Dams and dikes in navigable waters of the United States also require Department of the Army (DA) permits under Section 404 of the Clean

Water Act of 1977, as amended (33 U.S.C. 1344). (U.S. Army Corps of Engineers, Office of the Chief of

Engineers 1977). Processing a DA application under Section 9 will not be completed until the approval of the United States Congress has been obtained if the navigable water of the United States is an interstate water body, or until the approval of the appropriate state legislature has been obtained if the navigable water of the United States is an intrastate water body (i.e., the navigable portion of the navigable water of the United States is solely within the boundaries of one state).

b. Dredged or fill material. Section 404 of the Federal Water Pollution Control Act Amendments of 1972 charges the Secretary of the Army, acting through the Chief of Engineers, to regulate the discharge of dredged or fill material in the waters of the United States. The construction of dams, dikes, etc., is considered to be a discharge of fill material under Section 404. On March 27, 1975, the U.S. District Court for the District of Columbia directed the Corps of Engineers to extend its responsibility to regulate the

discharge of dredged or fill material under Section 404 to all waters of the United States (including territorial seas) and to revise its regulation accordingly. The term "waters of the United States" is a much broader term than "navigable waters of the United States." A final regulation was published on July 19, 1977 (U.S. Army Corps of Engineers, Office of the Chief of Engineers 1977).

c. Documentation for safety. Safety is one of the factors considered in reaching public interest decisions on applications for permits. The applicant for a permit to construct a dam is required to furnish documentation in order that the Corps may verify that the proposed dam has been designed for safety. No specific design specification or criteria are prescribed, and no independent detailed engineering reviews are performed. Further information on permit regulation and dam safety is given in Permit Regulation 33 Code of Federal Regulation 320.4(k) (U.S. Army Corps of Engineers, Office of the Chief of Engineers 1977).

Chapter 3

Civil Works Project Planning and Design Process

3-1. General

The civil works planning and design process for a new dam is continuous, although the level of intensity and technical detail varies with the progression through the different phases of project development and implementation. The phases of the process are reconnaissance, feasibility, preconstruction engineering and design (PED), construction and finally the operation, maintenance, repair, replacement and rehabilitation (OMRR&R). A brief description is given below. For more detailed guidance regarding each phase, refer to ER 1110-2-1150.

3-2. Problem Perception and Study Authorization

The typical civil works project has its beginning when a problem is perceived or experienced which is beyond the capability of local interests to alleviate and therefore Federal assistance is requested. At the request of one of its members, Congress may authorize a study of the problem (ER 1105-2-100).

3-3. Reconnaissance Phase

A reconnaissance study is conducted to determine whether or not the problem has a solution acceptable to local interests for which there is a Federal interest and if so whether planning should proceed to the feasibility phase. The reconnaissance study is Federally funded and is limited to 12 months with extension to 18 months under unusual circumstances. During the reconnaissance phase, engineering assessments of alternatives are made to determine if they will function safely, reliably, efficiently and economically. Each alternative should be evaluated to determine if it is practical to construct, operate, and maintain. Several sites should be evaluated and preliminary designs prepared for each site for cost estimating purposes. These preliminary designs should include the dam, the foundation for the dam and appurtenant structures and the reservoir rim. The reconnaissance phase consists

of preparing and reviewing proposed project plans, structuring the project features into the code of accounts, developing preliminary cost estimates, holding a Reconnaissance Review Conference (RRC) with a Technical Review Conference (TRC), if appropriate, and developing the engineering effort and budget required for the feasibility phase and the Initial Project Management Plan (IPMP). The reconnaissance phase ends with certification of the reconnaissance report.

3-4. Feasibility Phase

A feasibility study is conducted to investigate and recommend a solution to the problem based on technical evaluation of alternatives and includes a baseline cost estimate and a design and construction schedule which are the basis for congressional authorization. The feasibility study is cost-shared with the local sponsor and should be completed in 3 to 4 years. All of the project OMRR&R and dam safety requirements should be identified and discussed with the sponsor and State during the feasibility phase. A turnover plan (discussed in paragraph 3-1h), for non-Federal operated dams, that establishes a definite turnover point of the dam to the sponsor should be documented in the IPMP and in the Feasibility Report (ER 1105-2-100).

3-5. Preconstruction Engineering and Design Phase

The PED phase is conducted to verify, complete and document detailed design studies of a project as authorized or proposed with the Feasibility Report. Design costs for the PED phase are shared in the same percentage as construction. During the PED phase, which generally requires a period of about 2 years, activities necessary to ready the project for construction including preparation of plans and specifications (P&S) for the first construction contract are completed. It may be determined during the PED phase that a General Design Memorandum (GDM) or General Reevaluation Report (GRR) is necessary because the project has changed substantially since administration review of the feasibility report (with engineering appendix) or authorization, the project was authorized without a feasibility report, there is a need to readdress project formulation, or there is a need to reassess project plans due to changes in administration policy (ER 1110-2-1150 will be followed).

3-6. Construction Phase

This phase not only involved the actual construction of the project features, but includes design and preparation of P&S for subsequent construction contracts, review of selected construction contracts, site visits, support for claims and modifications, development of operation and maintenance (O&M) manuals, and preparation and maintenance of as-built drawings (ER 1110-2-1150).

3-7. Operation and Maintenance Phase

The project is operated, inspected, maintained, repaired, and rehabilitated by either the non-Federal sponsor or the Federal government, depending upon the project purposes and the terms of the Project Cooperation Agreement (PCA). For PCA projects and new dams turned over to others, the Corps needs to explain up front the O&M responsibilities, formal inspection requirements, and responsibilities to implement dam safety practices.

3-8. Turnover of Completed Dam Projects to Local Sponsors

As a result of the Water Resources Development Act of 1986, a number of flood control and multipurpose

dams have been authorized subject to the provision that the local sponsor is responsible for OMRR&R (see ER 1165-2-131).¹ All project OMRR&R and dam safety requirements must be identified and discussed with the local sponsor during the feasibility phase and documented in the IPMP and Feasibility Report. The local sponsor must comply with all State and Federal dam safety requirements. As the project design develops and the O&M manual is prepared, the sponsor should provide input and review the draft document. The sponsor should be made aware of its responsibilities for providing an adequate operational and technical staff or appropriate engineering services contract for project security, performance data, and timely remedial measures as required. The turnover of the project to the sponsor will occur immediately after the first periodic inspection. The sponsor must be made aware that after transfer of the project, the Corps is in a supporting role with respect to dam safety and will only participate in inspections and review performance data.

¹ Guidance on policy and procedures for the turnover of completed dam projects to local sponsors is given in Policy Guidance Letter No. 39, "Responsibilities of the Corps of Engineers and Local Sponsor to Ensure Safe Operation, Maintenance, Repair, Replacement and Rehabilitation for Flood Control and Multipurpose Dams Constructed Under the Provisions of PL 99-662," dated 13 November 1992.

Chapter 4 Operation and Maintenance

4-1. General

Problems may occur following many years of trouble-free operation of a dam. This is particularly so for flood control dams which may not be tested by a significant percentage of the maximum head for many years. Also, any period of prolonged severe storming or severe operation such as rapid drawdown warrants additional attention during and immediately after the operation. This is particularly true for control structures such as spillways, conduits, channels, and associated machinery. Another category of higher risk involves those dams of advanced age which may be progressively deteriorating. Rigorous and continuous vigilance, checking, and inspection, for as long as the dam is operational, are necessary for dam safety (James 1990, International Commission on Large Dams 1987, Morrison-Knudsen Engineers 1986, Schurer 1988). Dam operations management policy is covered in ER 1130-2-419.

4-2. Operation and Maintenance Manual

The O&M manual is prepared during the construction phase. The purpose of the O&M manual is to provide guidance and instructions to project personnel for proper operation and maintenance of the facility. A general outline for the O&M manual is given in Appendix I to ER 1130-2-304. The O&M manual contains a narrative summary of the critical features of the dam including design features with safety limits, the more probable failure modes that could lead to structure failure, and a history of problems and how they could adversely affect the structure under stress (ER 1130-2-419).

4-3. Instrumentation and Monitoring

All Corps of Engineers dams are required to have an adequate level of instrumentation to enable the designers to monitor and evaluate the safety of the structure during the construction period and under all operating conditions and furnish data on behavior for application to future designs. Each structure is provided with minimum instrumentation to measure hydrostatic pressure,

embankment seepage, and foundation underseepage and displacement of major elements of the structure. Strong motion accelerometers are installed in structures located in seismic regions. In the case of older structures, which were designed using criteria that have been revised due to changes in the state-of-the-art, instrumentation provides most of the data necessary to evaluate the safety of the structure with respect to current standards and criteria. After a project has been operational for several years, scheduled maintenance, repair, and replacement of instrumentation are included in the normal plan of operation (ER 1110-2-110). Detailed information on instrumentation for earth and rockfill dams is given in EM 1110-2-2300 and EM 1110-2-1908. Information on instrumentation for concrete dams is given in EM 1110-2-2200 and EM 1110-2-4300 (see also Lindsey et al. 1986, Keeter et al. 1986, Currier and Fenn 1986, and O'Neil 1989). Full reliance is not placed on instrumentation to forecast unsatisfactory performance, since it is impractical to install enough instrumentation to monitor every possible problem area. An extremely important adjunct to an adequate instrumentation program is visual observation to determine evidence of distress (Duscha 1982). Project personnel receive extensive training in basic engineering considerations pertaining to major structures, with procedures for surveillance, monitoring, and reporting of potential problems, and with emergency operations (discussed in Chapter 7).

4-4. Initial Reservoir Filling

a. General. The "initial reservoir filling" is defined as a deliberate impoundment to meet project purposes and is a continuing process as successively higher pools are attained for flood control projects. The initial reservoir filling is the first test of the dam to perform the function for which it was designed. In order to monitor this performance, the rate of filling should be controlled to the extent feasible, to allow as much time as needed for a predetermined surveillance program including the observation and analysis of instrumentation data (Duscha and Jansen 1988). A DM on initial reservoir filling has been required for all new Corps of Engineers reservoir projects since 1979.

b. Design memorandum. As a minimum, the DM on initial reservoir filling will include:

(1) The preferred filling rate and the available options to control the rate of reservoir rise.

(2) The surveillance necessary to detect most likely occurring problems.

(3) A plan for reading the instruments and evaluating the data.

(4) A plan for inspecting the dam and down stream areas.

(5) Instructions for observers on conditions that require immediate attention of personnel authorized to make emergency decisions.

(6) An emergency plan listing responsibilities, name, and/or positions, telephone numbers and radio frequencies to be used.

c. Existing Corps reservoir projects. Existing operational projects, where the maximum pool (top of flood pool) has not been experienced, will be reviewed for compliance with requirements as outlined in paragraph 4-4.b. For those conditions where contingency plans have not been documented and potential danger exists due to filling and/or impounded storage, a report is required outlining those plans. The document may be titled "Flood Emergency Plan" providing that additional initial filling requirements are deemed not to have significant potential impacts on the safety of the structure (EM 1110-2-3600).

4-5. Periodic Inspection and Continuing Evaluation

a. General. A formal program for periodic inspection and continuing evaluation of completed Corps of Engineers projects was established in 1965. Under this program, structures whose failure or partial failure would endanger the lives of the public or cause substantial property damage are periodically evaluated to ensure their structural safety, stability, and operational adequacy. Inspections and evaluations are performed by teams of experienced design, construction, and

operations engineers. The evaluations are aided by instrumentation programs (Duscha 1982). Instructions for periodic inspection and continuing evaluation of dams are given in ER 1110-2-100. Additional information on inspection of dams is available (Federal Emergency Management Agency 1979, Colorado Division of Disaster Emergency Services 1987, Reed 1987). The periodic inspection program has one potentially dangerous aspect in that engineers might be tempted to place too much reliance on it and assume that a project once inspected has a guarantee of safety until the next inspection. The thorough occasional inspection is invaluable but cannot take the place of day-to-day observation by operating personnel for detection of potentially dangerous problems at an early and repairable stage (James 1990).

b. Scope of inspections. Corps of Engineers civil works structures such as dams, powerhouses, and appurtenant dam structures (intake and outlet works, spillways, and tunnels) will be periodically inspected in accordance with procedures in Appendix A of ER 1110-2-100 to detect conditions of significant distress or operational inadequacy.

c. Frequency of inspections. The first periodic inspection is carried out immediately after topping out and prior to impoundment of the pool for new earth and rock-fill dams. The initial inspection of concrete dams is accomplished immediately prior to impoundment of reservoir water. The second inspection for new earth and rock-fill dams is made at a reasonable stage of normal operating pool. The second inspection of concrete dams is made when the reservoir water attains the normal operating pool, and in either case no later than one year after initial impoundment has begun. Subsequent inspections for earth and rock-fill dams and concrete dams are made at one-year intervals for the following three years, at two-year intervals for the next four years and then extended to five-year intervals if warranted by the results of the previous inspections (ER 1110-2-100).

d. Procedure. A systematic plan is established for the inspection of features related to the safety and stability of the structure and to the operational adequacy of the project. Operational adequacy means the inspecting, testing, operating, and evaluation of those components of the project whose

failure or failure to operate properly would impair the operational capability and/or usability of the structure. These components include, but are not limited to:

- (1) Flood and outlet control gates (including flood gates in levees and flood walls).
- (2) Navigation lock gates and valves.
- (3) Emergency closure gates.
- (4) Associated hoists and operating machinery (including safety devices such as limit switches and fail-safe interlocks).
- (5) Flood control pumps and related equipment.
- (6) Cathodic protection systems.

Details concerning the systematic inspection plan are given in Appendix A of ER 1110-2-100.

e. Reports.

(1) Pre-inspection brochure. A technical brochure is prepared in advance of each project inspection to familiarize inspection team members with general features of the project. This brochure includes a technical summary of the structural, material, and foundation conditions; instrumentation data; and a list of the deficiencies found in previous inspections, if pertinent, and the status of remedial actions recommended. Also, the brochure should include, as appropriate, pertinent project data, layout and typical section drawings, summaries of subsurface soil profiles and boring logs, and the checklist developed for conducting the inspection (ER 1110-2-100, Duscha and Jansen 1988).

(2) Initial and subsequent reports. A condition report will be prepared to present the results of each general project inspection. Report No. 1 (report of initial inspection) will provide a general project description and present the results of the initial inspection. Reports of subsequent inspections will be supplementary to the initial report and will focus on changed conditions noted since the previous inspection. A status report on recommended remedial measures not completed prior to approval of the previous inspection report will also be included (ER 1110-2-100, Duscha and Jansen 1988).

4-6. Reporting Distress

a. Guidance. Evidence of distress at, or potential failure of, dams is to be reported in accordance with the guidance set forth in ER 1110-2-101. Evidence of distress will be immediately reported to the district office. Where engineering evaluation of the evidence of distress indicates the need for immediate remedial action, the district commander will immediately report such conditions through command channels to the HQUSACE Dam Safety Officer who is the Chief of the Engineering Division, Directorate of Civil Works. Each USACE Command will also establish procedures for notification of the major subordinate command and district Dam Safety Officer and coordination of all information with their counterparts in the Emergency Management element. The HQUSACE Dam Safety Officer will notify the Director of Civil Works, and the Commander, USACE. If the HQUSACE Dam Safety Officer cannot be contacted, the reporting field office will follow the notification sequence as outlined in Appendix A of ER 1110-2-101.

b. Examples. Examples of evidence of distress include, but are not limited to:

(1) Significant sloughs, settlement, or slides in embankments such as earth or rockfill dams, urban levees, and bridge abutments or slopes of spillway, channels, locks, and dam abutments.

(2) Evidence of piping, muddy water boils in the area of a structure such as embankments, abutments, dam monoliths, lock walls, or cofferdams.

(3) Abnormal increase or decrease of flow from foundation drains, structural joints, or face drains of concrete dams.

(4) Any increase in seepage quantities through or under embankments or in abutments.

(5) Any increase or decrease in pore water pressure in either embankments or their foundations or abutments.

(6) Any increase or decrease in uplift pressures under concrete structures.

(7) Unusual vertical or horizontal movement or cracking of embankments or abutments.

(8) Significant cracking of mass concrete structures either during construction or after completion.

(9) Sinkholes or localized subsidence in the foundation of or adjacent to embankments or other structures.

(10) Excessive deflection, displacement, or vibration of concrete structures (e.g. tilting or sliding of intake towers, bridge piers, lock wall, floodwalls).

(11) Erratic movement, binding, excessive deflection, or vibration of outlet and spillway gates.

(12) Significant damage to any structure (e.g., barge damage to bridge piers or lock walls or ice flow damage to intake towers and access bridge piers).

(13) Significant damage to, or changes in, structures, foundations, reservoir levels, groundwater conditions, and adjacent terrain as a result of seismic events of local or regional areas. Special inspections of such damages will be made immediately following the event as described in ER 1110-2-1802.

(14) Any other indications of distress or potential failure that could inhibit the operation of a project or endanger life or property.

(15) Excessive vibration, binding, unusual noises, movements, or deflections of gate hoist operating equipment.

(16) Actual hydraulic equipment operating pressure in excess of 125 percent of the normal operating pressure. Electric motor operating equipment overheating or stalling.

(17) Erratic movement or unusual sounds, such as bumping, jumping, or popping of lock miter gates.

(18) Wire rope lifting cables or lifting chains having broken strands or deformed, worn, or severely corroded links.

(19) Frequent power interruptions.

(20) Excess movement of penstock flexible couplings.

(21) Penstocks or turbine spiral cases that show signs of distress such as deformation or cracking.

(22) Failure of major mechanical or electrical equipment at local flood protection projects.

Chapter 5 Rehabilitation and Modification of Dams

5-1. Dam Safety Rehabilitation

Rehabilitation or modification of Corps of Engineers dams for safety purposes is accomplished through the Major Rehabilitation Program and the Dam Safety Assurance Program.

5-2. Major Rehabilitation Program

The Major Rehabilitation Program is to allow accomplishment of significant, costly, one-time structural rehabilitation or major replacement work (other repairs related to dam safety are accomplished under the normal Operation and Maintenance program). The work under this program restores the project to its original condition to serve as originally intended. An example of dam safety work under this program would be the installation of a "cut-off" wall to control seepage through a dam. Projects approved for major rehabilitation require budget justification and other supporting data similar to the budget information prepared for construction projects. The Major Rehabilitation Program is limited to the major repair or restoration of main structures such as dams, locks, and powerhouses, exclusive of electrical, mechanical, and other equipment, except that such equipment may be included where it is essential to and integral with the feature of the project being rehabilitated. The Major Rehabilitation Program is not applicable to local protection projects, dams, or other works turned over to local interests for operation, maintenance, and major replacement (U.S. Army Corps of Engineers, Office of the Chief of Engineers 1977; ER 1130-2-500; Federal Emergency Management Agency 1992b; Wiseman 1987).

5-3. Dam Safety Assurance Program

a. General. The Dam Safety Assurance Program provides for modification of completed Corps of Engineers dam projects which are potential safety hazards in light of current engineering standards and criteria. This program is one part of the Corps'

numerous dam safety activities. The problems generally fall into two categories: hydrologic and seismic. The program is intended to facilitate upgrading of those project features which have design or construction deficiencies related to dam safety in order to permit the project to function effectively and as originally intended. In order to qualify, the modifications must be within the Chief of Engineers' discretionary authority and also must be such that they cannot be accomplished under routine maintenance. Projects approved for Dam Safety Assurance will require budget justification and other supporting data similar to the budget information prepared for construction projects. The Dam Safety Assurance Program may also be used to modify dams built by the Corps of Engineers and turned over to local interests to operate, maintain, replace, rehabilitate, and repair (ER 1130-2-419, ER 1165-2-119, ER 1110-2-1155, Walz 1990a).

b. Policy on hydrologic criteria. Since the Corps of Engineers began building dams, the policy has been that failure of a Corps of Engineers dam should not significantly increase the downstream hazard over the hazard which would have existed if the dam had not failed. However, new policy requires more analysis and documentation from the field offices when recommending improvements to hydrologically deficient dams (Duscha 1986). Additional background information on hydrologic criteria is available (National Research Council 1985; Federal Emergency Management Agency 1986a, 1986c; Wiseman 1987; Lave, Resendiz-Carrillo, and McMichael 1990; Task Committee on Spillway Design Flood Selection, Committee on Surface Water Hydrology, Hydraulics Division, American Society of Civil Engineers 1988). The following policy is used to make decisions on the merits of dam safety modifications to meet current hydrologic criteria given in ER 1110-8-2(FR) (ER 1110-2-1155).

(1) Planning for a dam safety modification will consider combination of structural design modifications as well as nonstructural measures, including downstream actions and changes in water control plans. The recommended plan should be for the dam safety modification which meets or exceeds the base safety condition (BSC). The BSC will be met when a dam failure related to hydrologic capacity will result in no significant increase in downstream hazard

(loss of life and economic damages) over the hazard which would have existed if the dam had not failed. Recommendations for any modifications that would accommodate floods larger than the flood identified as the BSC must be supported by an analysis that presents the incremental costs and benefits of the enhanced design in a manner that demonstrates the merits of the recommendation. Such enlargement of project scope may require Congressional authorization.

(2) Determination of the flood that identifies the BSC will require definition of the relationship between flood flows and adverse impacts (loss of life and economic damages) with and without dam failure for a range of floods that fully utilizes the existing structure up to the probable maximum flood (PMF). Selection of a BSC predicated on the hazard to life from dam failure will require supporting information to demonstrate that the safety of the population would actually be threatened. The evaluation should distinguish between total population downstream of a dam and the population that would likely be in a life threatening situation given the extent of prefailure flooding, warning time available, evacuation opportunities, and other factors that might affect the occupancy of the incrementally inundated area at the time the failure occurs. Appropriate freeboard necessary to accommodate potential wind and wave conditions will be included for all flood evaluations. The evaluation consists of two phases. Phase I is a comparative hazard analysis in which the threshold flood and the BSC are established. Phase II is the risk-cost analysis required if modifications for a flood larger than the BSC is recommended (ER 1110-2-1155). Examples of the analysis required to develop the base condition are illustrated in "Guidelines for Evaluating Modifications of Existing Dams Related to Hydrologic Deficiencies," Institute for Water Resources Report 86-R-7 (Stakhiv and Moser 1986).

(3) Selection of a recommended level of modification also should reflect concern for economy. Modification costs in the vicinity of the scale of improvement identified as the BSC should be examined for sudden increases in the cost/scale of improvement relationship. This type of change could occur, for instance, when a costly highway relocation is encountered near the scale of improvement identified as the BSC. An adjustment in the level of fix recommended may be warranted under these conditions. On the other hand, the large increase in costs may be justified if a

significant reduction in the hazard, with and without dam failure, is achieved.

(4) Measures to accommodate floods larger than the BSC may be warranted in some cases. When the project benefits that would be lost, and repair costs for failure are large enough, costs for structural modifications to prevent failure may be economically justified in spite of the low probability of the floods involved.

(5) Conduct of the analysis requires careful application of professional judgment for determining those parameters where data and modeling capability are limited. Therefore, the importance of documenting the logic assumptions, critical to the conclusions and recommendations drawn from the analysis, cannot be over-emphasized. Also, the evaluation should produce a significant amount of information needed throughout the decision making process, particularly in those cases where it is appropriate to proceed beyond the base condition. The information must be displayed in a format that assists the decision maker when evaluating the important trade-offs involved.

c. *Policy on seismic criteria.* The following policy is used to make decisions on the merits of dam safety modifications related to current earthquake design criteria (ER 1110-2-1155).

(1) Projects that retain or have the potential to retain a permanent pool, failure of which would result in loss of life, substantial property damage, or indirect loss such as the loss of essential emergency services provided by the dam, are required to survive and remain safe during and following the maximum credible earthquake event. Such projects shall additionally be capable of remaining operational with only minor repair during and after an operating basis earthquake (OBE). In the case of projects intended for short-term temporary flood storage, including those with low permanent pools, risk based assessments may be warranted. Combining a rare earthquake event with a rare hydrologic event demonstrates extremely low risk and therefore unwise use of funds.

(2) Technical requirements for selecting seismic design values and performing design analyses are contained in ER 1110-2-1806 (see also Federal

Emergency Management Agency 1985b). These criteria,

along with current state-of-the-art techniques, are intended to be used in such studies and analyses. Criteria levels, safety factors, and design methods are the same as that for new projects.

(3) Since judgment of ground motion parameters for design is based on geologic and seismic history, future strong seismic events may raise the design values against which stability should be analyzed. Should such a situation occur, the district, if convinced that the ground motion parameters have changed significantly enough to affect the safety of the project, shall prepare an evaluation report as detailed in paragraph 5-4.a.

(4) Strong motion accelerometers that have been placed on or around Corps dams are intended as a check on the design seismic resistance of the structure. If these instruments record ground motion parameters that, after analysis, are found to be below the values used in design but yet the structure received damage, a letter report (in the case of no expected future remedial action) or an evaluation report (in the case of anticipated remedial action) shall be written describing the situation and containing the district's recommendation.

(5) Seismic stability of auxiliary structures and devices, such as regulating outlet towers, spillway gates, retaining walls, hydraulic equipment, and electric lines, shall be upgraded where necessary to provide for dam safety, including requirements for dams to remain operational following the OBE. Auxiliary structures that do not affect dam safety or operational safety shall be judged for modification on economic or other grounds rather than dam safety.

(6) Seismic stability assessment for dam safety may also involve reservoir rim slides, effects of dam overtopping, movements of critical retaining walls, foundation or abutment changes, susceptibility of embankment dams to liquefaction, or any other feature that might contribute to dam failure.

5-4. Procedural Requirements

In order to identify and process work for inclusion in the Dam Safety Assurance Program, reporting and

EP 1110-2-13
28 Jun 96

design procedures given in ER 1110-2-1155 will be followed.

a. Dam Safety Assurance Evaluation Report. A reconnaissance will be conducted and a report prepared covering preliminary evaluation of work items considered necessary to upgrade the project. Format and content of the evaluation report will follow the requirements given in Appendix C of ER 1110-2-1155. Detailed field investigations and office studies will be kept to a minimum. The report will be designed to develop a basis for decision on:

- (1) The need for and justification of the modification for dam safety.
- (2) The appropriateness of funding under the Dam Safety Assurance Program.
- (3) Whether the work requires additional authorization.
- (4) Whether the work is subject to cost-sharing and identification and the views of the cost sharing partner.
- (5) The scope and cost of subsequent investigations.
- (6) The scope and cost of design requirements.

- (7) The estimated cost for construction.

If a determination on whether a problem exists cannot be made during the preparation of the evaluation report, then the need for special engineering investigation(s) will be identified and justified in the report. In those instances where there is need for both a special engineering investigation and follow-on investigations of known problems, both will be identified in the report. In addition, a plan of study and cost estimate for the special engineering investigation(s) will be included. Special engineering investigations are those extensive and complex investigations that may be required to determine the need for and/or scope of remedial construction. Special investigations include hydraulic modeling and geological and seismic investigations.

b. Design memorandum. For major dam safety modifications, a DM is usually prepared following approval of the evaluation report and any special investigations. Content of the DM will follow the requirements given in Appendix D of ER 1110-2-1155. The initial DM will present the results of the evaluation report and any special engineering investigations and make final recommendations concerning the need for and/or scope of the proposed modification. Included with this recommendation will be the estimated cost, schedule for construction, and design of the approved plan. This will provide the basis for preparation of plans and specifications.

Chapter 6 Emergency Action Plans (EAP)

6-1. General

a. Definitions.

(1) Emergency - An emergency, in terms of dam operation, is defined as a condition which develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action.

(2) EAP - An EAP is a plan of action to reduce the potential for property damage and loss of life in an area affected or about to be affected by a dam failure or large flood. It includes both the portion of a dam safety plan prepared by the Corps of Engineers and the complementary evacuation plan prepared by non-Federal interests.

b. Background. Corps of Engineers major subordinate command offices were instructed in March 1978 to begin preparation of flood EAPs for dams under their jurisdiction. Initially the effort was directed to delineate areas downstream from the dams that would be flooded in the event of dam failure. The product of these efforts was inundation area maps (ER 1130-2-419). In June 1980 the Corps of Engineers issued detailed instructions for the preparation of flood EAPs (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980, 1982). Subsequently, in August 1983, the Corps of Engineers distributed case studies of an EAP and evacuation plan to field offices (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a, 1983b).

6-2. Scope of Emergency Action Plan

Guidance (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980) has been provided for preparation of EAPs to deal with potential emergencies caused by

a. Spillway discharges sufficiently large to cause flooding in downstream areas.

b. Flooding upstream of dams due to backwater effects or high pool levels.

c. Dam failure.

6-3. Components of Emergency Action Plan

The principal components of EAPs (including agency responsible for preparation) are as follows (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980):

a. Emergency identification subplan (Corps of Engineers). The object of this subplan is to describe procedures and means for ensuring reliable identification and evaluation of existing or potential emergencies. The major elements of the subplan are:

(1) Listing of the conditions which could indicate an existing or potential emergency.

(2) Description of the data and information collection system, monitoring arrangements, inspection procedures, and other provisions for early detection of conditions indicating an existing or potential emergency.

(3) Procedures, aids, instructions, and other provisions for interpreting information and data to assess the severity and magnitude of any existing or potential emergency.

b. Emergency operations and repair subplan (Corps of Engineers). The objectives of this subplan are to guide immediate operational decisions in the event of various types of emergencies; identify the need for equipment, material, labor, and other necessities for carrying out emergency repairs; and describe the procedures for securing and employing needed equipment, material, labor, and other necessities. The major elements of the subplan are:

(1) Identification of the appropriate response to the type and severity of existing or potential emergencies.

(2) Emergency gate operation.

(3) Reservoir dewatering plan.

(4) Description of equipment and materials to be stockpiled for use in carrying out emergency operations and repairs.

(5) Assignments of responsibilities for carrying out emergency operations and repairs.

(6) Description of needs for equipment, material, and labor not available at the site which are needed to carry out each type of emergency operation or repair.

(7) Listing of nearby contractors and other sources of needed equipment, material, and labor and description of procedures for securing their assistance on an emergency basis.

c. Notification subplan (Corps of Engineers and non-Federal). The objective of this subplan is to describe the procedures and means for prompt notification of appropriate parties concerning existing or potential emergencies. The major elements of the subplan are:

(1) Inundation maps which show the area likely to be inundated and time of onset of dangerously high flows for each emergency condition for which plans are made (Corps of Engineers).

(2) Listing of vital services and facilities outside the area of inundation which will or may be disrupted by the level of inundation associated with each emergency condition for which plans are made (non-Federal).

(3) Listing of major secondary problems resulting from the level of inundation associated with each emergency condition for which plans are made (non-Federal):

(4) Evacuation maps which show (non-Federal):

(a) All areas which should be evacuated because of inundation, secondary problems, loss of services, isolation, or other reasons which are associated with each emergency condition for which plans are made.

(b) Major evacuation routes.

(c) Areas requiring priority in evacuation.

(d) Potential obstacles to timely evacuation.

(5) Listing of persons to be notified about each emergency condition for which plans are made and procedures for notification including description of primary and secondary means of communication to be used, listing of telephone numbers and addresses, and other information needed for reliable and prompt contact for (Corps of Engineers):

(a) Notifications internal to the Corps.

(b) Notifications from the Corps to principal local officials.

(c) Notifications from the Corps to other Federal officials.

(d) Distribution of warnings from the Corps to officials responsible for dissemination to the general public.

(e) Dissemination of warnings by the Corps directly to the general public in the immediate vicinity of the dam and reservoir.

(6) Example press releases for each emergency condition for which a plan is prepared and instructions for adaptation before their use to the specifics of an emergency situation including but not limited to (Corps of Engineers):

(a) Exact nature of emergency and degree of danger.

(b) Remedial action under way.

(c) Expected course of events and timing.

(d) Appropriate action for public to take.

(7) Description of the procedure and means for dissemination of warnings directly to the general public in the immediate vicinity of the dam and reservoir (Corps of Engineers).

d. *Evacuation subplan (non-Federal)*. Non-Federal officials are to be encouraged to develop evacuation subplans as a complement to the portion of dam emergency plans prepared by the Corps. The objectives of the evacuation subplan are to provide for the timely and safe evacuation of threatened areas and the minimization of property damage. The major elements of the subplan are:

- (1) Description of traffic control arrangements to expedite evacuation and passage of emergency vehicles and prevent accidental travel into dangerous areas.
- (2) Provisions for any necessary assistance to evacuees such as transportation and aid to invalids.
- (3) Arrangements for sheltering, feeding, and other care of evacuees.
- (4) Description of actions to be taken to reduce damages and other losses.
- (5) Arrangements for security of evacuated areas.
- (6) Arrangements addressing other aspects as required for the case at hand.

6-4. Number of Emergency Action Plans Required

A large number of hypothetical emergencies could be conceived by combining various causes for and assumptions about emergencies of one type or another. It is obviously impractical to prepare completely separate plans to address each potential emergency condition which might be postulated. Instead, each major portion of the emergency plan must be considered individually with respect to how many separate versions are necessary (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980):

a. *Emergency identification subplan (Corps of Engineers)*. Only one emergency identification subplan is required.

b. *Emergency operations and repair subplan (Corps of Engineers)*. The emergency operations and repair subplan consists of guidance and procedures for dealing with a variety of emergencies. One subplan is sufficient. The portion of its contents dealing with emergency responses should be divided according to the type of emergency addressed or action to be taken as, for example, the following:

- (1) Wave erosion.
- (2) Excess seepage.
- (3) Piping.
- (4) High pool conditions.
- (5) Malfunction of control gates.
- (6) Failure of discharge facilities.
- (7) Upstream dam failure.
- (8) Downstream dam failure.

c. *Notification subplan (Corps of Engineers and non-Federal)*. Notification subplans are to be prepared for three basic emergency conditions including: spillway design discharge without failure, spillway design discharge with failure, and failure at normal high pool level (top of flood control pool). Separate notification subplans are required for each emergency condition because:

- (1) Identification of the local officials to be notified of an existing or potential emergency depends on the area requiring evacuation which is associated with each emergency condition.
- (2) The need to notify other Federal agencies, the public in the immediate vicinity of the dam and reservoir, and other parties varies according to the nature of the existing or potential emergency.
- (3) The appropriate text of news releases depends on the emergency condition for which they are prepared.

d. Evacuation subplan (non-Federal).
Evacuation subplans will be prepared for conditions of:

- (1) Spillway design flood.
- (2) Spillway design flood with dam failure.
- (3) Dam failure with normal high pool level (top of flood control pool).

6-5. Emergency Action Plan Exercises

a. General. Testing of the EAP involving all participants is necessary to ensure that the plan is up-to-date and workable in practice under real-life conditions (Basinger 1990, Mahoney 1990, Gotzmer 1991).

b. Corps of Engineers requirements. ER 1130-2-419 states:

Division Commanders are directed to implement a dam safety training program for O&M personnel, with retraining every four years...Upon completion of initial safety training sessions for each project, operational training exercises for emergency situations shall be developed. These exercises shall be based on the more probable emergency situations that might occur on each major dam feature. A record shall be maintained at the project showing date, subject material, and personnel involved for each exercise conducted.

According to the "Emergency Action Planning Guidelines for Dams" developed by the Interagency Committee on Dam Safety and adopted by the Corps of Engineers (Federal Emergency Management Agency 1985, 1990b):

The dam owner should prepare scenarios for slowly developing, rapidly developing, and instantaneous emergencies and test the state of training and readiness of key personnel responsible for actions during an emergency to assure that they know and understand the procedures to be followed

and actions required. Any special procedures required for nighttime, weekends, and holidays should also be included. The tests should include a drill simulating emergency condition. Coordination and consultation with local government, law enforcement officials, and other organizations involved is desirable in order to enhance the realism of the test. Their involvement will perfect the close coordination with agencies necessary for a successful execution of the plan in an actual emergency. The test should be critiqued in writing and the plan should be revised to correct any deficiencies noted.

c. Types of exercises. FEMA has identified five types of exercises that constitute an exercise program, with each one building on the concepts of the previous exercise. These five types of exercises are (Federal Energy Regulatory Commission 1991; Federal Emergency Management Agency 1989a, 1989b; Gotzmer 1991):

(1) Orientation seminar. This involves bringing together persons with a role or interest in the EAP for discussion and to initiate plans for the annual drill or more in-depth exercise, and to become familiar with the roles, procedures, and responsibilities of those involved.

(2) Drill. A drill is the lowest level exercise. A drill test develops or maintains skills in a single emergency response procedure. The in-house drill tests the state of training and readiness of key personnel to ensure that they are fully cognizant of the procedures and actions required during an emergency. The drill should simulate an emergency condition at the dam under which the EAP would be implemented. Special procedures required for nighttime, weekends, and holidays should also be considered when developing the scenario. Testing of remote sensing instrumentation should be included. Coordination with local government, law enforcement officials, and other organizations involved is desirable. This will enhance the realism of the drill and ensure the accuracy of telephone numbers of persons to be notified. While a planned drill will allow persons involved to rehearse their roles, a surprise drill can be more educational and expose flaws in the EAP. Immediately following the

drill the responses to the emergency scenario at all levels will be reviewed and a critique prepared. The purpose of the critique is to identify lessons learned and deficiencies in the EAP including notification, priorities, and responsibilities assigned.

(3) Tabletop exercise. The tabletop exercise involves low stress, little attention to real-time, lower level of preparatory effort, and only rough attempts to simulate actual conditions. The tabletop exercise is conducted once a year. The focus is on training and familiarization with roles, procedures, responsibilities, and personalities of the persons involved. The tabletop exercise consists of discussion in a meeting format through one or more facilitators. The facilitator leads the conduct of the tabletop exercise and makes sure every participant responds to at least one message (described below) during the exercise. Effectiveness is determined by the impact of feedback from the participants on evaluating and revising policies, plans, and procedures. There is no deployment of resources or utilization of equipment. A narrative (or scenario) sets the scene for the simulated event by briefly describing what has happened and what is known up to the time of the exercise. The participants are provided with messages as the exercise progresses. The purpose of the messages is to provide updated information to the participants so that they will respond with an action or a decision. Once the exercise is completed, the results will be evaluated. An immediate post-exercise critique should be held followed by an evaluation report. The critique will be both oral and written and will provide the participants with a forum to gather and share information about what happened during the exercise, to describe what went right, and to identify what went wrong. The formal evaluation of the exercise consists of a written report based on observations and recommendations that come out of the critique, as well as the report(s) of the facilitator(s). Follow-up (the process of implementing the recommendations) is the final and critical stage of the exercise process. The advantage of a tabletop exercise is the modest commitment of time, cost, and resources. It provides an effective method of reviewing plans and implementing procedures and policies, and provides an opportunity for key personnel to become acquainted and review emergency responsibilities and procedures. The disadvantages of a tabletop exercise are that the

tabletop lacks realism and does not provide a true test of participants' capabilities.

(4) Functional exercise. The functional exercise is the highest level test that does not involve full activation of field personnel and facilities. The functional exercise is conducted once every 4 years. The functional exercise tests capabilities of the participants under a stress-induced environment with time constraints. Whereas a tabletop exercise provides opportunities throughout the exercise to stop and discuss actions and responses, the functional exercise is a time constrained test with limited opportunity for discussion. The functional exercise simulates actual emergency situations and responses of the participants without actual field deployment. The exercise is conducted with the participants co-located or located at their own facilities, with communications through expected emergency communication links. The functional exercise is based on a simulation of an emergency including a description of the situation, a master sequence of events list, a timed sequence of messages, and communication between participants and simulators. There are five functions or capabilities which should be included in a functional exercise:

(a) Alert, notification, and warning. This function tests the communication system and the messages to determine if they are appropriate and clearly understood. It verifies names and phone numbers on the notification list. Remote sensing equipment should be tested at the start of the exercise.

(b) Direction and control function. This function tests and evaluates the emergency operations capability and timely response. It includes the response to health problems, fire, downed power lines, and loss of life, including drownings.

(c) Evacuation. This capability is a key issue in the exercise as it tests the participants' understanding of the inundation maps. Experience indicates the inundation boundaries and the road names may not always be clear and fully understood (for example, road names used by local officials are often different from those on Geological Survey maps or state route maps). Maps are often revised as a result of this information.

(d) Shelters. This function reveals those shelters that should not be used because they are in the flood plain.

(e) Public information. This function tests the capability to issue accurate information during a dam failure event. Activation of the emergency operations center at the state or local level, as appropriate, should be encouraged. Apart from the actual participants in the functional exercise there are the exercise controller, exercise simulators, and exercise evaluators. The controller monitors the sequence of events as they unfold, the flow of messages, and the overall conduct of the exercise. The simulators send prescribed messages at the scheduled time, respond to unanticipated actions by participants with spontaneous messages, and maintain contact with the controller during the exercise. The evaluators observe the actions and decisions of the participants during the exercise and contribute, along with the exercise participants, to writing the evaluation report. As with the tabletop exercise, the critique, the evaluation report, and the follow-up to the recommendations in the report are important aspects of the functional exercise.

(5) Full-scale exercise. The full-scale exercise is the most comprehensive test and is intended to evaluate the operational capability of the emergency management system in a stress environment with mobilization of emergency workers, equipment, and

resources to demonstrate coordination and response capability. Full-scale exercises draw media and community attention to emergency preparedness; teach by doing; test total coordination, not only among policy and coordination officials, but also field forces; and point out physical resource capabilities and/or limitations. For agencies or local communities, full-scale exercises require considerable preparation and provide practical tests of "first-in" responders, including police, fire, and medical personnel. They test triage (allocation of treatment to disaster victims to maximize the number of survivors) procedures, on-scene management of resources, and coordination and communication through field command posts. As with the functional exercise, the controller is responsible for ensuring that the exercise starts on schedule. Simulators and evaluators keep a log of all significant events. During a full-scale exercise at Garrison Dam, North Dakota, conducted in August 1987, personnel were stationed at several locations in the District Office and at Garrison Dam to monitor and document phone and radio communications, decision making, and repair efforts (U.S. Army Engineer District, Omaha 1987). Each participant should log his actions as much as possible. Videotaping the exercise and critique is beneficial. The media should be included in any exercise plan to increase realism. At the conclusion of the full-scale exercise, the critique and evaluation report are important so that necessary follow-up action can be taken.

Chapter 7 Training

7-1. Overview

The Corps of Engineers has an extensive program for training its personnel in all matters related to its mission in water resources development. Much of the training is directly or indirectly related to dam safety. A comprehensive training program is conducted for dam operation and maintenance personnel. This program is designed to acquaint project personnel with basic engineering considerations pertaining to the major structures, with procedures for surveillance, monitoring and reporting of potential problems, and with emergency operations. The Corps of Engineers has a training course on "Design and Safety Surveillance of Embankment Dams" and supported the development of the Training Aids for Dam Safety (TADS) Program (Walz 1990b). In 1991, the Federal Energy Regulatory Commission initiated a training course on "Emergency Action Plan" (Gotzmer 1991). A listing of Government sponsored training courses relating to dam safety was prepared by the Interagency Committee on Dam Safety (ICODS) Subcommittee on Training (Federal Emergency Management Agency 1986b).

7-2. Training Program for Operations and Maintenance Personnel

a. Dam safety. Recognizing the important role which onsite operations and maintenance personnel have in dam safety, major subordinate command commanders were directed in 1978 to develop a training program which addresses the following items (ER 1130-2-419, United States Committee on Large Dams 1982):

(1) Discussion of basic typical design considerations for various types of construction, including hydraulic considerations and foundation factors.

(2) Procedures for monitoring potential problem areas.

(3) Dam safety features in design and construction.

(4) Normal operation, surveillance, monitoring, and reporting procedures.

(5) Emergency operations, surveillance, monitoring, and reporting procedures.

b. Exercises. Upon completion of the initial safety training at a new project, EAP exercises are developed based on the most probable emergency situations that might occur on each major dam feature. Operations and maintenance personnel are retrained every 4 years.

7-3. Corps of Engineers Training Course on Dam Safety

The Corps of Engineers Proponent Sponsored Engineer Corps Training (PROSPECT) program offers a course titled "Dam Safety in the Corps of Engineers". Through lectures, case histories, and structured student discussions, the course covers all aspects of a dam safety program. The course outlines technical considerations (hydrologic, seismic, geotechnical, electrical/mechanical and structural) as well as the operational requirements (operation, maintenance, surveillance, preparedness, training, and notification). The scope and implementation details of the Dam Safety Assurance Program are covered in detail. Presentations, video modules, case histories, and a walk-through inspection are used to effectively present a multidiscipline approach to the successful monitoring and evaluation of Corps of Engineers dams.

7-4. Training Aids for Dam Safety

a. Background. In 1986, the Corps of Engineers, along with 13 other Federal Agencies, all members of the Interagency Committee on Dam Safety, joined forces to develop a professionally prepared TADS Program. The TADS materials, as shown in Table 7-1, are arranged in three components that cover dam safety inspections, dam safety awareness and program development, and evaluations and remedial

actions (Federal Emergency Management Agency 1992b, Veesaert 1990).

b. Structure. The entire package consists of 21 self-paced individual instruction modules that focus on performance of job tasks. Each module features a workbook text. The material is presented in a straightforward, easy-to-manage manner. Each workbook contains a glossary of terms and a list of references from which to obtain additional information. Nine of the modules are supplemented with videotapes that illustrate certain concepts. Because the modules are self-contained, individuals may tailor a learning

program to meet specific work requirements or personal needs (Federal Emergency Management Agency 1992b, Veesaert 1990).

c. Utilization of the program. The TADS Program promises to offer a standardized approach to dam safety training. The Corps of Engineers, as one of the primary sponsors of the TADS Program, distributes the TADS materials to each Corps of Engineers field office through the Engineering Division, Directorate of Civil Works, HQUSACE. All MSCs and districts should have a complete set of modules including the videotape supplements.

Table 7-1
Training Aids for Dam Safety Modules

Safety Inspection of Dams
(for engineers with little or no inspection experience and technicians with some familiarity with dams)

Preparing to Conduct a Dam Safety Inspection
Documenting and Reporting Findings From a
Dam Safety Inspection
Inspection of Embankment Dams *
Inspection of Concrete and Masonry Dams *
Inspection of the Foundation, Abutments, and
Reservoir Rim
Inspection of Spillways and Outlet Works *
Inspection and Testing of Gates, Valves, and
Other Mechanical Systems *
Instrumentation for Embankment and Concrete
Dams *
Identification of Material Deficiencies *
Evaluation of Facility Emergency Preparedness

Data Review, Investigation and Analysis, and Remedial
Action for Dam Safety (for engineers with some applicability
for dam owners and operators)

The Dam Safety Process
Evaluation of Hydrologic Adequacy
Evaluation of Hydraulic Adequacy
Evaluation of Concrete Dams Stability
Evaluation of Embankment Dams Stability
and Deformation
Evaluation of Seepage Conditions

* Modules have videotape supplements.

Dam Safety Awareness, Organization, and Implementation
(for dam owners and operators, with some applicability
for inexperienced engineers, technicians, administrators,
and the general public)

Dam Safety Awareness *
How to Organize a Dam Safety Program
How to Organize an Operation and Maintenance
Program
How to Develop and Implement an Emergency
Action Plan *
Identification of Visual Dam Safety Deficiencies *